

44. The battery of claim 29 further comprising a current collector comprising graphite paper, the current collector being in electrical contact with the positive electrode or the negative electrode.

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REMARKS

Claims 29-44 and 52-57 are pending. Claims 55-57 are withdrawn from consideration. Claims 29 and 34 have been amended to correct minor typographical errors, and the specification has been amended to correct a typographical error. In addition, the specification has been amended to update references to copending applications. No new matter is introduced by these amendments.

All of the pending claims stand rejected. Applicants respectfully request reconsideration of the rejections based on the following comments.

Restriction/Election

The Examiner withdrew claims 55-57 newly submitted with the Amendment of April 30, 2001 as being directed to a non-elected invention. However, claims 55-57 depend from elected claim 29. A restriction is only acceptable if the distinct inventions are being claimed **and** if a significant burden results from the examination of the additional claims along with the elected claims. See MPEP §803. In the present case, since the claims are dependent on the elected claims, Applicants with all due respect cannot see what significant additional burden is raised by claims 55-57. Applicants respectfully request examination of claims 55-57.

Specification

The Examiner objected to the specification based on an assertion that the title was not descriptive. Applicants have amended the title to be more descriptive of the presently claimed invention. Applicants respectfully request withdrawal of the objection to the title.

In addition, the Examiner noted that an application number was missing on page 53, line 16. This application number has been inserted along with the missing application number at page 37, line 3, and references to other copending applications have been updated.

Rejections Under 35 U.S.C. §112

The Examiner rejected claims 29-44 and 52-54 under 35 U.S.C. §112, second paragraph as being indefinite. The Examiner raised several specific issues regarding the claim language. These are discussed in the order raised. Applicants thank the Examiner for a careful reading of the claims.

First, the Examiner objected to the terminology in the claims of "less than about." The Examiner asserts that this phrase is indefinite because "less than" defines a lower limit and "about" contradicts the lower limit. Applicants respectfully disagree with this view. The use of "about" in this context is no more imprecise than in other contexts, and the term "about" is an accepted claim term. The term "about" just indicates that the precise boundaries of the limit do not need to be exactly specified since it is not possible to test all parameters along a continuum to evaluate where the noted advantages are of particular importance. Applicants have selected values that clearly differentiate the prior art and provide advantages discussed in the specification. A person of ordinary skill in the art will recognize that insignificant differences in the cut-off values will not alter the significant features of the invention or attempt to capture any unpatentable subject matter. Thus, Applicants believe that the claims are clear with respect to their use of the term "about."

With respect to claim 34, Applicants have replaced "comprising" with "comprises."

With respect to claims 36 and 38, the Examiner indicated that the term "derivatives" is unclear. Claim terms take their ordinary meaning unless given a different meaning in the specification. In the present case, the claims take on their ordinary meaning.

Merriam Webster's Collegiate Dictionary, 10th Edition, defines a derivative as "a chemical substance related structurally to another substance and theoretically derivable from it." In the present context, the derivative of the inorganic materials would clearly include the compounds with modest amounts of intercalated lithium, dopants and the like. These derivative materials would be identifiable as the principle material with minor modifications. In some sense, the derivatives could be considered as a variation of the materials themselves. Therefore, the recitation of the materials themselves may be interpreted by a person of ordinary skill in the art to include the derivatives. The addition of the term "derivative," therefore, makes explicit what otherwise may be implicit. From this perspective, the explicit inclusion of the derivatives possibly makes the claim clearer rather than less clear. Applicants respectfully maintain that claims 36 and 38 are definite as filed.

Applicants respectfully request withdrawal of the rejection of claims 29-44 and 52-54 under 35 U.S.C. §112, second paragraph as being indefinite.

Rejections Under 35 U.S.C. §103

The Examiner rejected claims 29-44 and 52-54 under 35 U.S.C. §103(a) as being unpatentable over Oak Ridge National laboratory Bulletin of September 1, 1998 (the Oak Ridge Bulletin) in view of U.S. Patent 5,482,797 to Yamata et al. (the Yamata patent). The Examiner cited the Oak Ridge Bulletin for disclosing thin film batteries. The Examiner cited the Yamata patent for disclosing secondary batteries with submicron particles. However, Applicants do not believe that the combined disclosures lead a person of skill in the art to Applicants' claimed invention. Applicants respectfully request reconsideration of the rejections based on the following comments.

The Oak Ridge Bulletin is specifically a description of the formation of thin **film** materials. These materials are deposited by sputtering, vapor deposition and the like, which

inherently are film-forming processes. There is no teaching, suggestion or motivation for forming thin batteries by other techniques.

The Yamada patent discloses carbon particles useful for the intercalation of lithium as an anode active material. The size of the carbon particles relates to the capacity of the particles. See, for example, column 4, lines 8-22. In addition, there particles form aggregates ranging in size from about 0.1 to 80 microns. See, for example, column 3, lines 66-7, column 4, lines 12-14 and column 7, lines 39-42. **There is no teaching, motivation or suggestion that the particle size can be relevant for structural features of the battery.** Furthermore, there is no teaching regarding the **agglomerates** and the handling of these to form a smooth electrode, as claimed by Applicants.

Advantages regarding the improved capacity of nanoscale particles have been demonstrated also for cathode active materials. See, for example, U.S. Patents 5,952,125, 6,130,007 and 6,225,007. However, **the ability or desirability to process nanoparticles into thin electrodes is not taught or suggest by the cited art.** Specifically, the processing approaches to arrive at Applicants' claimed structures are not found in the prior art. Therefore, there are **two conceptual gaps** between the combined disclosures of the Oak Ridge Bulletin and the Yamada patent and Applicants' claimed invention. Since the cited art does not teach or suggest that particle properties can be used advantageously to alter electrode properties and since the cited art does not teach or suggest how to process particles to form thin and smooth electrodes as presently claimed, the combined disclosures of the references does not render Applicants' claimed invention obvious.


Applicants respectfully request withdrawal of the rejection of claims 29-44 and 52-54 under 35 U.S.C. §103(a) as being unpatentable over of the Oak Ridge Bulletin in view of the Yamata patent.

CONCLUSIONS

In view of the foregoing, it is submitted that this application is in condition for allowance. Favorable consideration and prompt allowance of the application are respectfully requested.

The Examiner is invited to telephone the undersigned if the Examiner believes it would be useful to advance prosecution.

Respectfully submitted,



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Peter S. Dardi
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ATTACHMENT
MARKED-UP AMENDMENTS

In the Title

Please substitute the following amended title for the title as currently on record:

BATTERIES WITH THIN ELECTRODES

In the Specification

At page 11, line 31 to page 12, line 7, please replace the paragraph with the following:

The use of exclusively gas phase reactants is somewhat limiting with respect to the types of precursor compounds that can be used conveniently. Thus, techniques have been developed to introduce aerosols containing reactant precursors into laser pyrolysis chambers. Improved aerosol delivery apparatuses for reaction systems are described further in commonly assigned and copending U.S. Patent Application Serial Number 09/188,670, now U.S. Patent 6,193,936 to Gardner et al., entitled "Reactant Delivery Apparatuses," filed November 9, 1998, incorporated herein by reference.

At page 18, line 30 to page 19, line 16, please replace the paragraph with the following:

Aerosol generator 182 can operate based on a variety of principles. For example, the aerosol can be produced with an ultrasonic nozzle, with an electrostatic spray system, with a pressure-flow or simplex atomizer, with an effervescent atomizer or with a gas atomizer where liquid is forced under significant pressure through a small orifice and fractured into particles by a colliding gas stream. Suitable ultrasonic nozzles can include piezoelectric transducers. Ultrasonic

nozzles with piezoelectric transducers and suitable broadband ultrasonic generators are available from Sono-Tek Corporation, Milton, NY, such as model 8700-120. Suitable aerosol generators are described further in copending and commonly assigned, U.S. Patent Application Serial No. 09/188,670, now U.S. Patent 6,193,936 to Gardner et al., entitled "REACTANT DELIVERY APPARATUSES," incorporated herein by reference. Additional aerosol generators can be attached to junction 186 through other ports 192 such that additional aerosols can be generated in interior volume 188 for delivery into the reaction chamber.

At page 27, line 24 to page 28, line 4, please replace the paragraph with the following:

In one preferred embodiment of a commercial capacity laser pyrolysis apparatus, the reaction chamber is elongated along the light beam to provide for an increase in the throughput of reactants and products. The original design of the apparatus was based on the introduction of purely gaseous reactants. The embodiments described above for the delivery of aerosol reactants can be adapted for the elongated reaction chamber design. Additional embodiments for the introduction of an aerosol with one or more aerosol generators into an elongated reaction chamber is described in commonly assigned and copending U.S. Patent application serial No. 09/188,670, now U.S. Patent 6,193,936 to Gardner et al., entitled "Reactant Delivery Apparatuses," incorporated herein by reference.

At page 29, lines 4-23, please replace the paragraph with the following:

The improved reaction system includes a collection apparatus to remove the nanoparticles from the reactant stream. The collection system can be designed to collect particles in a batch mode with the collection of a large quantity of particles prior to terminating production. Alternatively, the collection system can be designed to run in a continuous production mode by

switching between different particle collectors within the collection apparatus or by providing for removal of particles without exposing the collection system to the ambient atmosphere. A[n] preferred embodiment of a collection apparatus for continuous particle production is described in copending and commonly assigned U.S. Patent application serial number 09/107,729, now U.S. Patent 6,270,732 to Gardner et al., entitled "Particle Collection Apparatus And Associated Methods," incorporated herein by reference. The collection apparatus can include curved components within the flow path similar to curved portion of the collection apparatus shown in Fig. 1.

At page 35, lines 13-33, please replace the paragraph with the following:

The conditions to convert crystalline VO_2 to orthorhombic V_2O_5 and 2-D crystalline V_2O_5 , and amorphous V_2O_5 to orthorhombic V_2O_5 and 2-D crystalline V_2O_5 are described in copending and commonly assigned U.S. Patent application serial number 08/897,903, now U.S. Patent 5,989,514 to Bi et al., entitled "Processing of Vanadium Oxide Particles With Heat," incorporated herein by reference. Conditions for the removal of carbon coatings from metal oxide nanoparticles is described in U.S. Patent Application Serial No. 09/123,255, entitled "Metal (Silicon) Oxide/Carbon Composite Particles," incorporated herein by reference. The incorporation of lithium from a lithium salt into metal oxide nanoparticles in a heat treatment process is described in copending and commonly assigned U.S. Patent Application Serial No. 09/311,506 to Reitz et al., entitled "Metal Vanadium Oxide Particles," and in copending and commonly assigned U.S. Patent Application Serial No. 09/334,203 to Kumar et al., entitled "Reaction Method For Producing Ternary Particles," both of which are incorporated herein by reference.

At page 36, line 24 to page 37, line 5, please replace the paragraph with the following:

Because of their small size, the primary particles tend to form loose agglomerates due to van der Waals and other electromagnetic forces between nearby particles. These agglomerates can be dispersed to a significant degree. The secondary or agglomerated particle size depends on the approach used to disperse the particles following their initial formation. The degree of dispersion generally depends on the fluid/ liquid used to disperse the particles, the pH, ionic strength and the presence of dispersants, such as surfactants. Nanoparticles produced by laser pyrolysis generally can be well dispersed, as described further in copending and commonly assigned U.S. Patent Application Serial No. [___/___,___] 09/433,202 to Reitz et al., filed on November 4, 1999, entitled "Particle Dispersions," incorporated herein by reference.

At page 39, lines 6-18, please replace the paragraph with the following:

Several different types of nanoscale electroactive particles have been produced by laser pyrolysis with or without additional processing. The production of vanadium oxide nanoparticles and the production of batteries based on these particles are described in copending and commonly assigned U.S. Patent Application Serial No. 08/897,778, now U.S. Patent 6,106,798 to Bi et al., entitled "Vanadium Oxide Nanoparticles," and U.S. Patent 5,952,125 to Bi. et al., entitled "Batteries with Electroactive Nanoparticles," both of which are incorporated herein by reference. Surprising high energy densities have been obtained with these vanadium oxide nanoparticles.

At page 39, lines 19-26, please replace the paragraph with the following:

Similarly, silver vanadium oxide nanoparticles have been produced, as described in copending and commonly assigned U.S. Patent Applications Serial Nos. 09/246,076, now U.S. Patent 6,225,007, [to] and 09/311,506 [to], both entitled "Metal Vanadium Oxide Particles," both of which are incorporated herein by reference. For these materials surprisingly high specific capacities have been observed.

At page 39, line 33 to page 40, line 17, please replace the paragraph with the following:

Furthermore, lithium manganese oxide nanoparticles have been produced by laser pyrolysis along with subsequent heat processing, as described in copending and commonly assigned U.S. Patent Applications Serial No. 09/188,768 to Kumar et al., entitled "Composite Metal Oxide Particles," Serial No. 09/203,414, now U.S. Patent 6,136,287 to Horne et al., entitled "Lithium Manganese Oxides and Batteries," and 09/334,203 to Kumar et al., entitled "Reaction Methods for Producing Ternary Particles," all three of which are incorporated herein by reference. It has been observed that nanoscale lithium manganese oxide particles placed in a cathode of a lithium based battery can cycle reversibly over a larger voltage range than bulk materials. The use of nanoscale lithium manganese oxide particles in lithium based batteries is also described in U.S. Patent 5,807,646 to Iwata et al., entitled "Spinel Type Lithium-Manganese Oxide Material, Process for Preparing the Same and Use Thereof," incorporated herein by reference.

At page 40, lines 18-24, please replace the paragraph with the following:

In addition, tin oxide nanoparticles have been produced by laser pyrolysis, as described in copending and commonly assigned U.S. Patent Application Serial No. 09/042,227, now U.S. Patent 6,200,674 to Kumar et al., entitled "Tin Oxide Particles," incorporated herein by reference. Tin oxide particles are suitable for use as electroactive material in a negative electrode of a lithium based batteries.

At page 42, line 31 to page 43, line 9, please replace the paragraph with the following:

Lithium ion batteries use particles of a composition that can intercalate lithium into the negative electrode. The particles can be held in the negative electrode with a binder. Suitable intercalation compounds include, for example, graphite, synthetic graphite, coke, mesocarbons, doped carbons, fullerenes, niobium pentoxide, tin alloys, SnO₂, lithium titanium oxide, and mixtures, composites and derivative thereof. The production of tin oxide nanoparticles is described in copending and commonly assigned U.S. Patent Application Serial No. 09/042,227, now U. S. Patent 6,200,674 to Kumar et al., entitled "Tin Oxide Particles," incorporated herein by reference.

At page 52, line 33 to page 53, line 21, please replace the paragraph with the following:

Several different approaches can be used to produce extremely thin electrodes. For example, nanoparticles can be dispersed to form a dispersion or slurry of the nanoparticles. The dispersion can include electroactive nanoparticles, electrically conductive nanoparticles and a binder, if used. Suitable dispersants have a reasonably high vapor pressure such that they will evaporate relatively quickly after the electrode layer is formed. The dispersant preferably dissolves the binder such that the binder mixes relatively uniformly with the particles. A variety of organic solvents, such as alcohols, ketones, acetonitrile, esters, ethers and combinations thereof, can be used as the dispersant, depending on the particular binder. Surfactants or the like can be used to further the dispersion of the nanoparticles. The formation of dispersion of nanoparticles is described further in U.S. Patent Application Serial No. [___/___,___] 09/433,202 to Reitz et al., filed on November 4, 1999, entitled "Particle Dispersions," incorporated herein by reference. Generally, the dispersions should contain from about 5 weight percent solids to about 60 weight percent solids.

Claims As Amended

The claims have been amended as follows:

29. (Amended) A battery comprising:
a positive electrode;
[an] a negative electrode; and
a separator between the positive electrode and the negative electrode,
wherein at least one of the electrodes has an average thickness less than about 10 microns and
comprises electroactive particles having an average primary particle diameter less than about 500
nm.

34. (Amended) The battery of claim 29 wherein the negative electrode comprises
[comprising] a lithium intercalation compound.